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ABSTRACT

During the 1994-95 school year, the Eisenhower Regional Consortium for Mathematics and Science Education at Appalachia Educational Laboratory (AEL) conducted the Scope It Out project to provide training and technical assistance to educators in using the microscope as a learning tool in a standards-based curriculum. This publication is a compilation of selected lessons, developed by teachers involved with the project, that demonstrate using microscopes in the classroom for inquiry and experimentation. Topics include the microscope as a teaching and learning tool, assessing students using the microscope, organization and selection of classroom lessons, laboratory safety, and lessons submitted by teachers. Appendices contain sample class safety rules guidelines and references list for laboratory safety from the Tennessee Science Curriculum Framework. (JRH)

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Scope It Out:

Standards-Based Microscope Lessons for the Middle School

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Kimberly A. Suiter

May 1996

A publication of the

Eisenhower Regional Consortium for Mathematics and Science Education at AEL

Appalachia Educational Laboratory • Charleston, West Virginia

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AEL's mission is to link the knowledge from research with the wisdom from practice to improve teaching and learning. AEL serves as the Regional Educational Laboratory for Kentucky, Tennessee, Virginia, and West Virginia. For these same four states, it operates both a Regional Technology Consortium and the Eisenhower Regional Consortium for Mathematics and Science Education. In addition, it serves as the Region IV Comprehensive Assistance Center and operates the ERIC Clearinghouse on Rural Education and Small Schools.

The Eisenhower Regional Math/Science Consortium at AEL collaborates with educators to improve mathematics and science education. Specifically, the Consortium identifies and shares exemplary mathematics and science instructional materials and provides technical assistance to help teachers, administrators, and college faculty use new teaching methods and assessment strategies.

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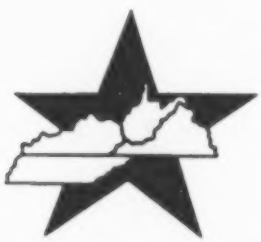

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Table of Contents

Introduction 1

Microscopes as a Teaching and Learning Tool 3

Assessing Students Using the Microscope 9

Organization and Selection of Classroom Lessons 11

Laboratory Safety 13

Lessons for the Microscope Submitted by Kentucky Teachers 15

Lessons for the Microscope Submitted by Tennessee Teachers 23

Lessons for the Microscope Submitted by Virginia Teachers 31

Lessons for the Microscope Submitted by West Virginia Teachers 39

References 47

Appendices 49

Introduction

During the 1994-95 school year, the Eisenhower Regional Consortium for Mathematics and Science Education at Appalachia Educational Laboratory (AEL) conducted the Scope It Out project to provide instructional materials, resources, and professional development to fifth- through eighth-grade teachers in AEL's four-state Region (Kentucky, Tennessee, Virginia, and West Virginia). The project provided training and technical assistance to educators in using the microscope as a learning tool in a standards-based curriculum.

At Consortium-sponsored workshops across the Region, more than 180 teachers from 104 counties were given classroom sets of microscopes, prepared slides, and blank slides for use in their classrooms. The materials and workshops provided educators the opportunity to learn both about microscopes and about ways to teach science concepts and processes using microscopes. The workshops established a foundation for creating a connected curriculum and promoted the National Science Education Standards as a guide for high-caliber classroom performance.

Teachers were asked to submit to the Consortium at a later date lessons they developed that demonstrate using microscopes in the classroom for inquiry and experimentation. This publication is a compilation of selected lessons. The booklet is intended to be a supplemental resource for teachers with students in Grades 5-8 in the AEL Region and across the country.

Microscopes as a Teaching and Learning Tool

Microscopy: What Is It?

Microscopy refers to the use of a microscope. It could be in the setting of a school laboratory, where students are learning about the structure of the cell, or in an operating room where a surgeon is using a microscope to reconnect a severed limb. In each case the use of the microscope is important, and the basic function of the microscope is the same: to make objects appear larger than they actually are.

As educators we often focus on the facts about the microscope but forget to emphasize the real-life applications of microscopes in fields such as medicine, criminology, and environmental science. If we want our students to learn, we must find the connections between the school curriculum and the real world.

Why Use the Microscope?

Several hundred years ago our society was searching for explanations to common events. Beliefs that frogs came from rocks, fish from leaves, and mold from spirits (spontaneous generation) severely inhibited the growth of knowledge in areas such as technology, medicine, and hygiene. The invention and refinement of the microscope provided a tool that enabled people to challenge and discard misconceptions in science and move toward a healthier, more productive society.

Applied technology, evident in tools such as the telescope and the microscope, has enabled scientists to discover and learn more about objects in our universe that are too small or too far away to be seen by the naked eye. Telescopes have allowed scientists to explore the vast universe and see things, such as other planets, comets, and recent collisions between a comet and the planet Jupiter. Microscopes, on the other hand, have allowed scientists to explore the ways in which cells work and the abundant life existing in pond water and on our skin. Countless lives have been saved as a result of understanding how the microscopic world affects people and other living things.

The microscope is truly an indispensable tool in the science classroom of today. It provides teachers and students with the opportunity to examine living and nonliving things too small for the eye to see without assistance. In addition, the laboratory experience is seen as an essential part of the science curriculum. Authors, such as Klanin (1988) and White and Tisher (1990), strongly support the laboratory component of the science curriculum.

Other authors have made a case for the inclusion of microscope activities in all areas of scientific investigation and learning. Laboratory investigations have shown a positive relationship toward developing logical thinking (Fensham, 1990), enhancing perspective and critical thinking (Tasker, 1981), promoting increased problem-solving skills (Butts, 1989), and fostering increased organizational and process-related skills (Burden, 1990).

The use of the microscope is called for by many organizations including the National Research Council in its publication of the *National Science Education Standards* (NSES), the American Association for the Advancement of Science (AAAS) in *Project 2061: Benchmarks for Science Literacy* (Benchmarks), and the National Science Teachers Association in *The Content Core* (CC).

In the NSES, microscopes are recommended as a tool in many standards, such as developing student understandings about the organization of living things, diversity among and adaptations of living things, science as a human endeavor, the structure of living things, and the interdependence of organisms. In these standards, the microscope is a critical tool for fully embracing the identified standard.

In *The Content Core,* the microscope is a tool for students to use in understanding prefixes used in scientific notation, the organization of the cell, body functions, plant structures, and linear measurements. In addition, the microscope assists in the exploration of magnification, simple and compound lens configurations, and concave and convex lenses.

In the AAAS *Benchmarks For Science Literacy* document, the microscope is the tool to examine single-celled organisms and to identify the various types of cells found in living things. The microscope is recommended to demonstrate the concepts of scale in the mathematical world and technology in the design world to explore historical perspectives.

The microscope is essential for doing science in the laboratory setting. For this reason, the national standards and benchmarks recommend the integration of the microscope into every science curriculum.

Microscopes: A Brief History

The first microscopes were probably made by Dutch spectacle makers experimenting with their handiwork and magnifying images. The first compound microscopes applied to scientific endeavors were made by Zacharias Jansen (or his father) around the year 1595. These early models were nothing more than a telescoping tube with a lens at each end. Focusing was accomplished by sliding the tube into position and lighting was believed to be a problem.

The initial use of the microscope was not widely accepted until the 1660s when Marcell Malpighi published his papers in support of William Harvey's theories of blood circulation and Robert Hooke published *Micrographia*. Malpighi first used the microscope to view capillary action in fish by using bent metal "fish plates" to hold the fish motionless while it was being viewed. However, Hooke made the microscope an accepted scientific tool by publishing his theories on cells. These cells, the basic structures of all living things, were named for the small monastery rooms of which they reminded Hooke.

By the mid-1600s, microscopes were mounted on tripods and stands. It was during this time that Anton Van Leeuwenhoek made his impact on the scientific world. In 1673 the Royal Society of London published his letters in *Philosophical Transactions*. In these letters he described simple activities to be performed with the microscope and provided the first description of protozoa, bacteria, and red blood cells.

Leeuwenhoek's microscopes provided magnification in the 200' power range with a resolution of two microns. This standard remained in effect until modern glass grading techniques and materials advanced the microscope to a capability of viewing objects having lengths less than 0.0000001 m (1×10^{-7} m).

The early 1900s saw the next revolution in microscopy with the development of the electron microscope. These electron microscopes, which use a beam of electrons to reveal microscopic details, can magnify objects up to 250,000 times.

The microscope is currently used as an instructional tool in classrooms around the world. It is also used in the field of medicine (fiber optics) to assist in surgery, to reveal tissue disorders, and to diagnose illnesses related to the blood and circulation. In short, the microscope has changed our world for the better by allowing us to see it from a new perspective.

How the Microscope Works: Exploring Focal Length

The basic working part of the microscope is the lens, or a combination of lenses, used to magnify objects. The term **magnify** means to "make something appear larger," and the typical magnifying lens is a convex lens that is thicker in the middle and thinner on the edges. (See Figure 1). We can demonstrate magnification using a common hand lens.

One of the best ways to help students learn about magnification is to use a hand lens and conduct the following activity. Instruct the students to hold the lens at arm's length and look through the lens at a person or object across the room. Ask, "What do you see?"

Next, tell the students to move the lens very close to their eyes and look at the same object. "What do you see this time?" Provide the

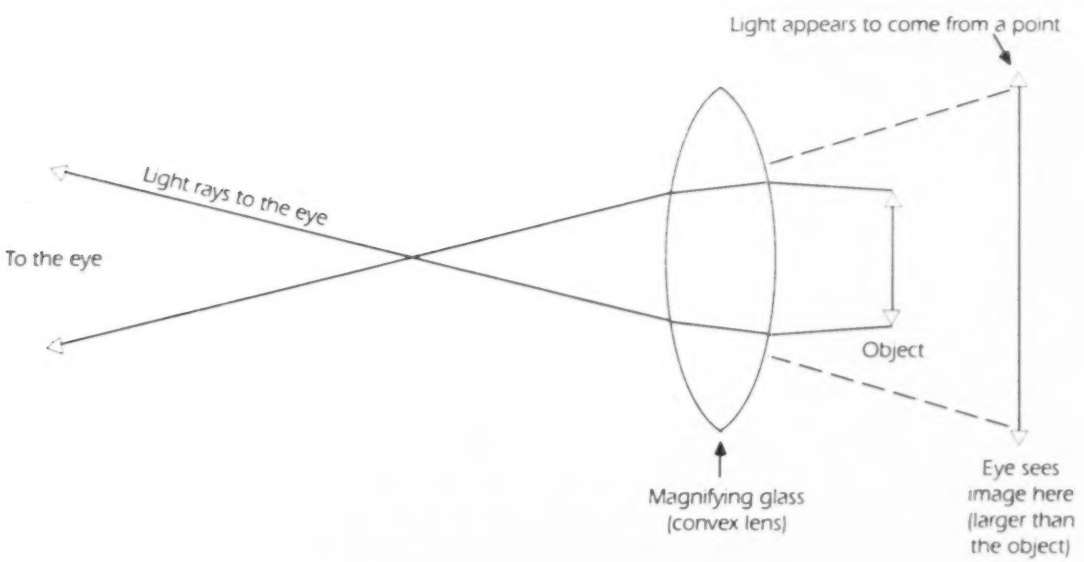


Figure 1. Magnifying Glass

students with the following explanation:

> With any luck, the first image you saw was inverted, or turned upside down, and the second image was right side up. This change is due to what is known as the focal length of the lens. As light passes into the lens, the curved edges redirect the light and change the way you see the things on the other side of the lens.

Provide Figure 2 to the students and tell them this picture illustrates some facts about focal length, which they can use as a hand lens to see for themselves.

Instruct the students to use the hand lens to look at the print of a newspaper. Ask, "What do you notice about the magnified letters?"

Tell the students:

- Hold the hand lens above a printed letter and magnify the images as much as possible without letting the image get blurred.
- Measure the distance from your face to the lens and from the lens to the paper (you can measure the distance with the help of a partner or simply hold the end of a measuring tape in the same hand as the hand lens and measure the distance to your eye and then to the hand you are viewing).
- Record the information and take a few minutes to examine the information and create a statement about it.
- Extend your arm and look through the magnifying glass at an object across the room.
- Measure as before.

If you are doing this activity with a group, record the information on a class data recorder at the front of the room and plot the information on a class graph. Take a few minutes and discuss the information on the data recorder and the graph. Use the information in Figure 2 to develop a possible explanation about the information collected.

To continue exploring focal length, instruct the students: "Take the hand lens and focus it on the object you used earlier. Use a second lens between your eye and the first lens to refocus the image.

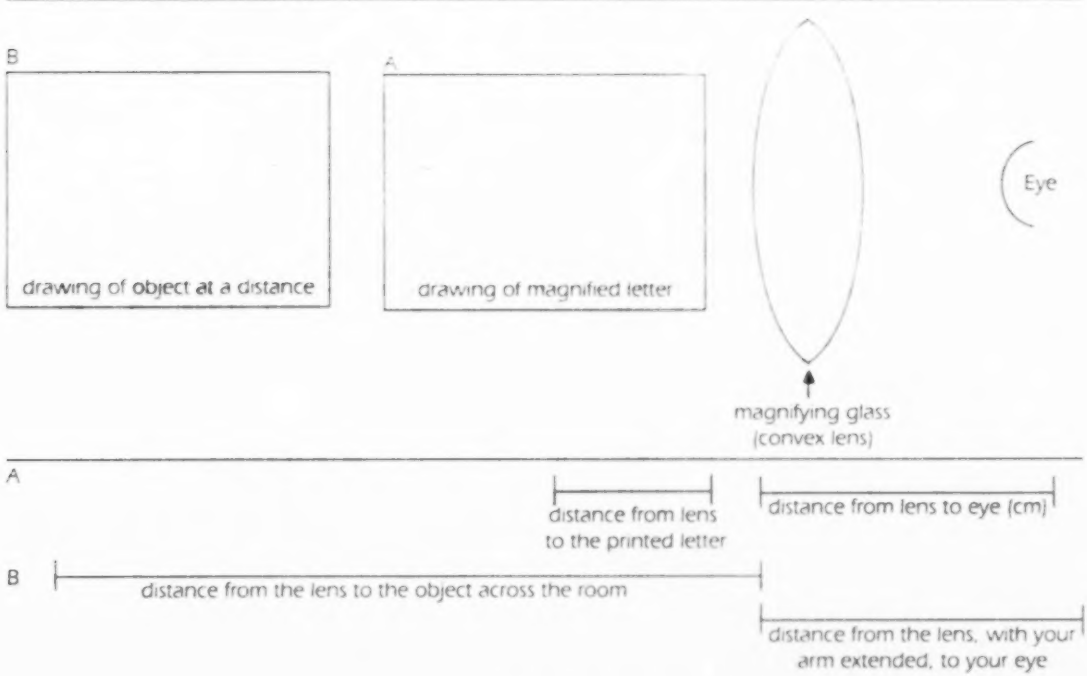
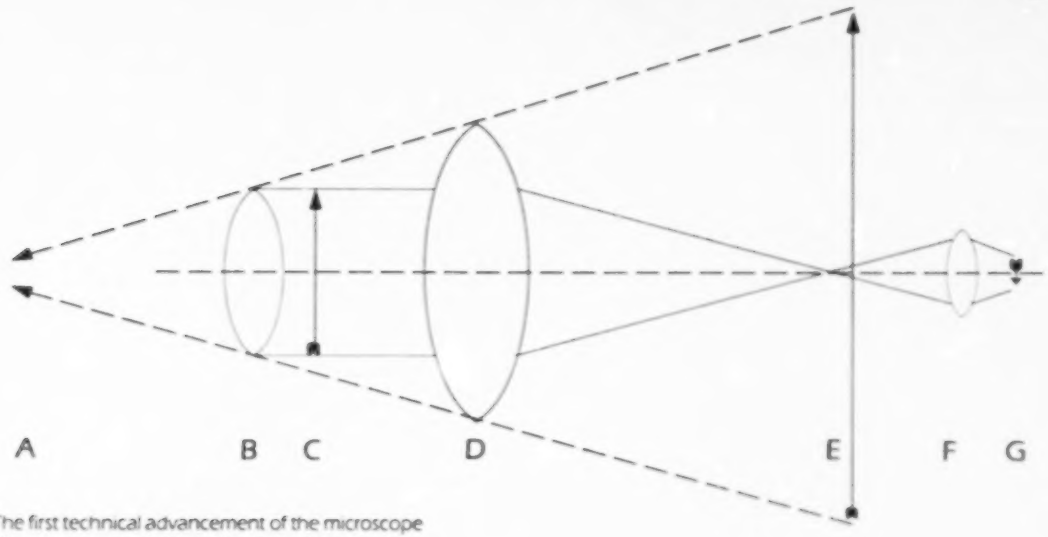


Figure 2. Focal Length and Perspective



The first technical advancement of the microscope after Jansen was revision of its optics from the two-lens system to the three-lens system, early in the century. In this diagram, B is the eye-lens, D is the field lens, and F is the objective lens. The eye views at point A. It has been said that Robert Hooke was the first to use this, by using the two-lens "Huygens" eyepiece that was standard for the telescope. This allows for better conservation of light from the object, while avoiding a very large eye-lens from which the eye must be held an uncomfortable distance away. This three-lens system remains the standard configuration of microscopes today, except that each lens may be made of a combination of close lenses.

Figure 3. Three-lens System

What do you see that is different from before?"

Provide students with a copy of Figure 3 and the following summary of the activity:

> The previous activity represents how a compound microscope (one with multiple lenses) works. The first lens captures and redirects the image and the second (and possible third) lens magnifies the image by redirecting light. In using the microscope, you will be focusing through the same process you used to focus the image with two lenses by moving the lenses. This simple process is the same one that allows eyeglasses and contact lenses to impact vision and binoculars and telescopes to help us to see things far away.

Assessing Students Using the Microscope

When we begin changing the way we teach, we need also to examine the strategies we use to assess student performance and progress. The inclusion of microscope activities at the fifth- through eighth-grade levels may be very new to some teachers and will require an exploration of alternatives to traditional assessment strategies.

Criteria for Good Assessment

The criteria for good assessment are currently being debated across the nation. We, as educators, need to ensure that assessment, curriculum, and instruction are meshed to form a cohesive unit for student learning. In *A Toolkit for Professional Developers: Alternative Assessment* (1994), four indicators of good assessment are identified. These indicators, presented in the form of questions, are:

- Is it clear what goals, skills, and/or content are to be covered on the assessment?
- Are the goals and objectives best assessed using performance or alternative assessment strategies?
- Does the assessment focus on identified student objectives and avoid irrelevant or unimportant content and skills?

- Does the assessment deal with enduring themes or significant knowledge within or across disciplines?

If we design assessments with these four questions in mind, we have moved a long way toward aligning curriculum, assessment, and instruction.

Portfolios as an Effective Assessment Tool for Microscope Activities

One of the more effective assessment strategies for microscope activities is constructing portfolios to represent student work. A portfolio is a systematic gathering of student work to represent learning and accomplishment. Some things that might be included as portfolio entries are:

- drawings and narratives about what is seen through the microscope,
- group projects showing microscopic features of living things,
- work that demonstrates the identification of features in and an understanding of the function of living things,
- student-generated research related to an aspect of the microscopic world, and
- work that demonstrates the use of the microscope in problem solving.

Organization and Selection of Classroom Lessons

Classroom lessons were submitted by teachers who participated in Consortium-sponsored workshops. Six lessons were selected from each state in the AEL Region for inclusion in this book.

The lessons included in this publication were reviewed for content, process, and applicability to the National Science Education Standards (1995). These lessons should be viewed as starters for using the microscope in the classroom. As a teacher you will need to personalize the lessons by including your own individual questions, processes, and expected results that relate to your instructional and curriculum goals. Lessons are categorized by the name of the state represented by the teacher who submitted the lesson and reflect the National Science Education Standards of Science As Inquiry, Science in Personal and Social Perspectives, or to the History and Nature of Science.

The standard of Science As Inquiry is intended to be a step beyond science as a process. The inclusion of this standard in the curriculum involves engaging students in active participation and learning and serves five essential functions:

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- assists in the development and understanding of scientific concepts,
- helps in "knowing how we know" science,
- develops an understanding of the nature of science,
- develops the skills necessary to become independent inquirers and thinkers, and
- develops dispositions to use the skills, abilities, and habits of mind associated with science. (National Research Council, 1995)

The standard of Science in Personal and Social Perspectives refers to the ability of students to explore and make informed decisions about scientific ideas as those ideas relate to the real world. This standard includes information and activities about hazards and risks, resources, personal health, technology, and society as an interactive and dynamic system.

The standard History and Nature of Science promotes the understanding that science reflects history and is an ongoing, changing, and challenging undertaking. Included in this standard are the exploration of science as a human endeavor, the nature of science, the history of science, and the development of a historical perspective of science.

Laboratory Safety

Student safety should always be foremost in the minds of teachers in the laboratory setting. In the activities presented in the following sections the staff of the Eisenhower Regional Consortium for Mathematics and Science Education at AEL strongly recommend that teachers follow the expectations for a safe working environment presented by the National Research Council in the National Science Education Standards (1995).

The following laboratory safety guidelines were developed by the Tennessee Science Curriculum Framework writing team and are included in the state science curriculum framework adopted December 1995. These guidelines reflect the recommendations for laboratory safety promoted by the National Research Council.

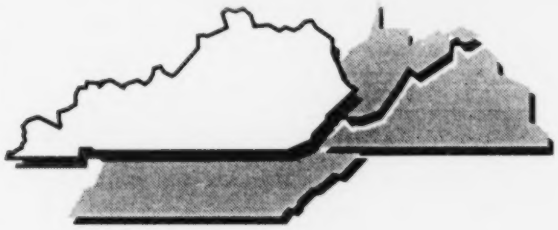
The Tennessee State Department of Education has graciously given permission for these guidelines to be reprinted in this booklet. In addition to the general description of the laboratory safety provided below, sample safety guidelines for various grade levels are included as Appendix A, and a reference list for laboratory safety is included as Appendix B.

Safety Guidelines

Teachers of all grade levels—kindergarten through college—must consider a number of issues when thinking about safety in their science classrooms. Those issues include: chemical storage, hazard, and disposal; equipment instructions, proper uses, and safety guidelines; first aid procedures; laboratory specific safety issues, room arrangement, and safety equipment instructions. To ensure laboratory safety, teachers should also

maintain an up-to-date chemical inventory, date all chemicals as they are received, keep a Material Safety Data Sheet (MSDS) on file for all chemicals being stored or used, store all chemicals in a safe and appropriate manner (see the Flinn Catalog), and know and follow the district chemical Hygiene Plan. If you are unsure of how to use a piece of equipment, how to properly store chemicals, what potential dangers exist for a particular chemical or piece of equipment, or of other safety issues, be sure to ask. If no one at your school or district is able to assist you, you might contact a local university, the poison control center, the local fire department or the chemical/equipment manufacturer.

Sample safety guidelines are included in Appendix A. The lower elementary guidelines were written primarily for purposes of class discussion and communication with parents. The upper elementary/middle school and middle/high school guidelines were written not only for purposes of class discussion and communication with parents but also for written communication with students. These guidelines are intended to provide you with minimum safety and conduct rules. You may need to alter or add to these guidelines in order to make them more specific to your classes. Many science methods books provide thorough descriptions of science safety guidelines (e.g. Frederick and Cheesebrough, 1993), which might provide you with additional ideas. For all grade levels, pictures and posters can be placed around the room to remind students of the safety tips—these can be purchased through many scientific supply houses and teacher centers.



Lessons for the Microscope Submitted by Kentucky Teachers

Teacher	School	Lesson
Mary E. Bach	Bath County Middle School Owingsville	Root Hairs
Billie Prince	Ballard Memorial Middle School Barlow	Differences in Classes of Insects
Jessica Thomas	Carlisle County Elementary School Bardwell	Exploring Three Types of Bacteria
Renee B. Adams	Emma Morgan Elementary School Paducah	Toothpaste Textures
Carla Parish	North Marshall Middle School Calvert City	World Within Our World
Betty Harrison	Carr Elementary School Fulton	It's a Small World

Root Hairs

Submitted by: Mary E. Bach
Bath County Middle School
Owingsville, Kentucky

Objective of Lesson: Students investigate the role root hairs play in the growth of a plant by observing, recording, analyzing, and hypothesizing about plant growth. All roots have root hairs that bridge the gap between the plant and dissolved nutrients in the soil and water necessary for survival. Students will learn through inquiry that broken root hairs inhibit a plant from meeting its water and nutrient needs.

Materials Required for Each Small Group of Students:

3 identical seeds

3 pots containing potting soil

Microscope (s)

Hand lens

Ruler

Instructions to the Teacher:

1. Divide students into small groups (4-5 people) and instruct each group to plant three identical seeds in individual pots. Label pots A, B, and C.
2. After 7 to 10 days when the plants germinate and leaves appear, have students observe the growth process at the beginning of each class period.
3. When first true leaves appear, ask students to use a ruler to measure and record the data on a graph.
4. Do the following for each pot:

   Pot A: Do not disturb.

   Pot B: Carefully remove the plant keeping the roots as intact as possible. Examine the structure of the root hairs. Remove 1/2 of all root hairs and carefully repot in the same pot.

   Pot C: Roughly yank the plant. Remove all root hairs. Repot in the same pot.
5. Have students observe all plants over the next 10 to 14 days. Students should record the data related to the growth of the plant.
6. At the end of approximately 14 days, ask students to use the microscope or hand lens to examine the roots from Pots A, B, and C. Have the students write their answers to the following questions and discuss their observations in their small groups.

   a. How are the roots in the three pots alike? How are they different?

   b. What is the connection between the root hairs and the growth of the plant?

Differences in Classes of Insects

Submitted by: Billie Prince
Ballard Memorial Middle School
Barlow, Kentucky

Objective of Lesson: Students observe the differences and similarities between two orders of insects. Bees are in the order of hymenoptera and grasshoppers are in the order of orthoptera. Students will learn through inquiry that animals and plants are classified by differences in their physical appearance.

Materials Required for Each Pair of Students:

Microscope

Flashlight

Pencil and colored pencils

Six pieces of paper

Slide

Antennae of bee

Wing of bee

Antennae of grasshopper

Foreleg of grasshopper

Wing of grasshopper

Instructions to the Teacher:

1. Divide students into pairs and provide them with the required materials. Ask one student in each pair to examine grasshopper structures under the microscope while the other student examines bee structures.
2. Ask students to trade slides after they have completed their observation. Ask each student to draw and label parts of both insects.
3. After students have completed their observation and drawing, ask them to write a paragraph discussing the similarities and differences between the two insects. Have them include the following information:
   a. How does the structure of antennae, legs, and wings help "do a job" for the insect?
   b. Does the size of the insects' wings limit how large it grows? Explain your answer.
   c. Were the differences between these two insects great enough to say they were in fact from two different classes?

Exploring Three Types of Bacteria

Submitted by: Jessica Thomas
Carlisle County Elementary School
Bardwell, Kentucky

Objective of Lesson: Students investigate the special characteristics of the three major classes of bacteria: spirilla, bacilli, and cocci. They will learn through inquiry that the three classes of bacteria can be recognized by their shapes, which will be visible through the microscope. These differences account for the ways in which these bacteria attack and infect living things.

Materials Required for Each Student or Group of Students:

Microscopes

Prepared slides of the three types of bacteria (spirilla, bacilli, cocci)

Instructions to the Teacher:

1. Depending upon the number of microscopes available to the class, ask students to work individually or in small groups.
2. Ask students to observe slides of each of the three bacteria and draw what they see.
3. Ask students to prepare a chart that lists the distinguishing characteristics.
4. Have students discuss the answers to these questions in small groups:
   a. How are the three bacteria different?
   b. Why is shape used as a strategy for classifying living things?
   c. What advantages could each shape have for the growth and dispersion of each type of bacteria?

Toothpaste Textures

Submitted by: Renee B. Adams
Emma Morgan Elementary School
Paducah, Kentucky

Objective of Lesson: Students use inquiry to observe, collect data, and make informed decisions related to consumer choices.

Materials Required for Each Group of Students.

Microscope slides

Toothpicks

Water

Toothbrushes for every student

At least four brands of toothpaste

Instructions to the Teacher:

1. Divide students into small groups.
2. Provide each group with materials.
3. Have students prepare a chart listing the four brands of toothpaste with sections labeled "texture by touch," "texture by taste," and "texture by microscope."
4. Direct students to rub a sample of toothpaste between their fingers to feel the texture.
5. Ask students to record on their chart whether the toothpaste felt smooth, gritty, etc.
6. Ask each student in the group to brush his/her teeth with a different brand of toothpaste. Ask the students to record their impressions of the texture by taste.
7. Select one student in each group to use a toothpick to smear a slide with toothpaste, add a drop of water, and put on a coverslip.
8. Have students in each group view the slide and draw an image for later comparison. After viewing the slide, write a description of each toothpaste including qualities of texture.
9. Repeat with three different brands of toothpaste.
10. Compare the brands for texture, grit, and appearance.
11. Ask students to draw a conclusion about which toothpaste they would choose and explain why.
12. Have students discuss in small groups or with the entire class the following questions:
    a. What appears to be the main reason for using toothpaste to clean teeth?
    b. What could happen if the amounts of the toothpaste ingredients were changed?
    c. Why should you use toothpaste instead of just water to brush your teeth?

Note: Your local dentist or grocer may be willing to contribute toothbrushes to your classes.

World Within Our World

Submitted by: Carla Parish
North Marshall Middle School
Calvert City, Kentucky

Objective of Lesson: Students explore the impact of technology on our world by using the microscope as an aid to enhance vision. Activities based on this standard allow students to compare the eye and the microscope to realize that although the human eye has limitations, instruments exist to enable humans to see beyond their limits.

Materials:

National Geographic Society video, *The Invisible World* (available through National Geographic, 60 minutes, $29.95, Carolina Scientific Materials, F6-49-1006-V).

Microscopes

Slides

Several specimens of common objects or prepared slides

Instructions to the Teacher:

1. Show students the video *The Invisible World*.
2. Ask students to collect 10 things they would like to observe through the microscope.
3. Help students to prepare the specimens for viewing.
4. Have students view the slides under the microscope and draw what they see.
5. Students can discuss as an entire group, in small groups, or write their responses to the following questions:
   a. How has the development of the microscope helped the quality of human life?
   b. What are the most noticeable differences between looking at an object with just your eye and with a microscope?

It's a Small World

Submitted by: Betty Harrison
Carr Elementary School
Fulton, Kentucky

Objective of Lesson: Students will use a microscope to view remnants of living things and make predictions about the lifestyle of the organisms being studied. They will understand that the development of the microscope has significantly impacted the way in which we view the world around us. It has allowed us to come to know about bacteria and illness, the structure of the atom, and the way living things work to survive.

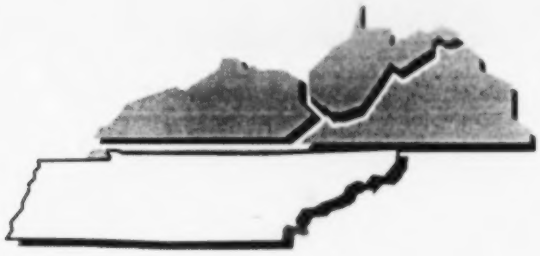
Materials for Each Pair of Students:

7 small samples of the remains of living things for viewing (insects, leaves, fabric, etc.)

Microscopes and slides

Instructions to the Teacher:

1. Ask students to bring in seven remnants of living things that they would like to examine under a microscope.
2. Have students work in pairs to prepare slides, view with a microscope, observe, and record their observations about any four of the remnants brought in by the class.
3. Ask each student to write a paragraph about the life of one organism (and remnant) they observed. Students should make use of appropriate resources such as texts, reference books, and the Internet to develop their paragraph.
4. Either as a writing assignment, or for class discussion, have the students address the following activities:
   a. Describe an additional use for each remnant by our society. Be creative and don't think about the remnant in traditional ways. Be prepared to use your observations and your imagination.
   b. Draw a picture to show what the remnant looked like under your microscope and represent how the remnant would be used in a nontraditional manner.



Lessons for the Microscope Submitted by Tennessee Teachers

Teacher	School	Lesson
Martha D. Bland	Milan Middle School Milan	What Is That?
Paula Smith	Hillcrest Elementary School Troy	What Is the Difference Between a Cell and a Tissue?
Tammy L. Pack	North Clinton Elementary School Clinton	Microscopic Buddies
Donna Gardner	Unicoi County Middle School Erwin	Stomate Functions
Marta Martin-Stapleton	Hancock Central Elementary School Sneedville	Pollution Particles
Glenea Mays	Camp Creek Elementary School Greeneville	Crystals

What Is That?

Submitted by: Martha D. Bland
Milan Middle School
Milan, Tennessee

Objective of Lesson: Students will observe and compare objects using the microscope to develop their observation and classification skills.

Materials:

Ten numbered microscopes (number with note cards)

Ten prepared and numbered slides (slides of stem material, skin, vegetable skin, fish scales, etc.)

Timing device

Paper and pencil

Instructions to the Teacher:

1. Tell the class, "Today is mystery day." Point out the 10 (or more) microscopes with different specimens located around the room. Remind students not to move the slides or disturb the microscopes as they look at the slides.
2. Divide the students into small groups and have them make up a list numbered from 1 to 10. Tell them they will have 100 seconds to record what they think the items are that they see in the microscopes.
3. Start the timer and say "switch" after 100 seconds. Tell students to record their observations and get ready to move to the next station.
4. After all ten (10) mystery stations have been observed, allow students to return to any station they were not sure of to recheck their observation.
5. Reproduce the blank chart on the board or on an overhead projector.
6. Ask students to share their lists of the 10 mystery slides.
7. Compile the class's answers on the chart.
8. When all choices are recorded, reveal the true identity of each mystery slide.
9. Discuss with the class how difficult it was to identify the samples.
10. Generate a list of uses for the microscope in our society.

		Mystery Station									
(For board)		1	2	3	4	5	6	7	8	9	10
GROUP	1										
	2										
	3										
	4										
	5										

What Is the Difference Between a Cell and a Tissue?

Submitted by: Paula Smith
Hillcrest Elementary School
Troy, Tennessee

Objective of Lesson: Students identify and define the terms "cell" and "tissue" by exploring animal specimens. Exploring systems through the examination of cells and tissues is a basic strategy used by scientists to understand our world.

Materials:

Model of an animal cell

Posters of cells and tissues

Iodine

Onion

Forceps

Microscopes

Microscope slides and coverslips

Frog blood cells (prepared)

Tissue slides (bone, muscle, skin, blood, nerve)

Dropper

Instructions to the Teacher:

1. Ask students to review a reference book for information on cells and tissues.
2. Provide students with cell slides, microscopes, forceps, dropper, onion, and iodine.
3. Ask students to examine each of the prepared slides and record their observations.
4. Ask students to compare and contrast their observations. What are the similarities and differences that exist among the speciments?
5. Discuss the following questions with the class:
   a. Identify a slide which represented cells. Describe the characteristics that led you to identify it as such.
   b. Identify a slide which represented tissue. Describe the characteristics that led you to identify it as such.
   c. How were you able to tell the difference between the two types of specimens?

Microscopic Buddies

Submitted by: Tammy L. Pack
North Clinton Elementary School
Clinton, Tennessee

Objective of Lesson: Pairs of middle grade students and elementary grade students work as partners to explore, observe, and identify samples of several substances by analyzing the similarities and differences among the available samples.

Materials:

Sugar	Salt
Flour	Baking Soda
Unprepared slides	Microscopes
Powdered sugar	Baking Powder
Coffee creamer	Water
Baggies	Starch
Clear tape	

Instructions to the Teacher:

1. Pair two older students with two younger students in groups of four.
2. Place one cup of each powder in a Baggie and label it with a number.
3. Ask the older students in each group to show the younger students how to prepare a wet slide of each sample powder. Ask them to label the slide with a corresponding sample number using a small piece of clear tape.
4. Ask each group to complete an observation sheet while they view slides.
5. When finished, compare observation sheets from all groups.
6. Have students discuss or draw pictures of variations they observed.
7. Have groups add items to the observation list to compare/contrast.
8. Have students deduce what each sample is. Groups might take another small sample and use other properties to identify the powder.
9. Students should determine whether substances are solutions or suspensions.
10. Discuss the following questions with the groups:
    a. What characteristics did your group use in determining the type of powder being viewed?
    b. Describe the difference between a solution and a suspension. Which samples were solutions and which were suspensions?
11. The older students who worked with the younger students can do a writing exercise describing their experiences as a tutor in this activity.

Stomate Functions

Submitted by: Donna Gardner
Unicoi County Middle School
Erwin, Tennessee

Objective of Lesson: Students explore the respiratory processes of plants to understand how the plant retains enough water to survive. They will observe that the stomata is the structure that allows water to be released and regulates pressure within the plant.

Materials:

Hand lens	Microscope
Forceps	Clock or watch
Coverslip	Metric ruler
Paper towel	Microscope slide
Salt water	Dropper

Lettuce leaf soaked in distilled water

Instructions to the Teacher:

1. Provide materials to all students or set up work stations for small groups of students. Have students use a hand lens to observe both the upper and lower surfaces of a lettuce leaf.
2. Have students tear a 5 cm square piece off the lettuce leaf. Direct them to bend the square of the lettuce in half. Show them how to use forceps to remove a thin layer of epidermis.
3. Direct students to use a dropper to place a drop of distilled water on a microscope slide. Place the thin layer of epidermis in the drop. Cover with a coverslip.
4. Have students observe the epidermis under the microscope looking for the pair of bean-shaped guard cells.
5. Next, have students use the dropper to place a drop of salt water next to the edge of the coverslip. Have them touch a piece of paper towel to the edge of the coverslip on the side opposite the drop of salt water. The salt water should flow under the coverslip. Tell students to wait five minutes and then observe the epidermis under the microscope.
6. Have students discuss the following questions in small groups:
   a. What changes did you observe after the salt water was applied?
   b. Does this experiment have any application to farming and agriculture?

Pollution Particles

Submitted by: Marta Martin-Stapleton
Hancock Central Elementary School
Sneedville, Tennessee

Objective of Lesson: Students examine the impact on the environment with the invention of machines using internal combustion. Students will learn that there are risks related to the development of new technology. The internal combustion engine allowed people to move themselves and products faster and cheaper, but created byproducts (e.g., carbon monoxide and soot) that have a negative impact on the environment.

Materials:

Several clean microscope slides

Petroleum jelly

Microscopes

Broom handle or a long stick

Rubber bands or tape

Car (operated and supervised by an adult)

Instructions to the Teacher:

(*Safety note*: This activity, especially the particulate collecting, should be done only with close adult supervision.)

1. Smear a thin coating of petroleum jelly on the middle portion of a glass microscope.

   (For comparison, prepare a second slide to use as a control.)

2. Use the rubber bands or tape to affix the slide to the broom handle or stick.

3. Older students may hold the first slide 4-5 centimeters from the end of an auto engine that is running for about a minute or two. Make sure the petroleum jelly is facing the exhaust. Caution: The car should be in an open area to allow for sufficient ventilation. Keep students observing the process away from the exhaust. Remind everyone to avoid breathing the exhaust.

4. Put the slide under the microscope and look at the exhaust particles. Compare to the control slide.

5. Ask students to describe what they discovered on the slide.

6. Have students write about the implications these particles have toward people and the environment. Ask students to share their papers with the class and discuss.

Crystals

Submitted by: Glenea Mays
Camp Creek Elementary School
Greeneville, Tennessee

Objective of Lesson: Students will investigate the structure of crystals by using the microscope to compare crystalline structure and patterns.

Materials Required for Each Student:

Measuring cup (250 ml)

Black construction paper

Water

Magnifying lens

2 tablespoons of Epsom salts

Microscope

Spoon

Small paint brush

Several clean slides

Instructions to the Teacher:

Part I:

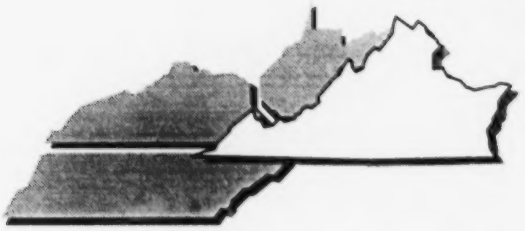
1. Provide each student with a measuring cup.
2. Direct students to fill the measuring cup to the 1/4 mark with water.
3. Have them add two tablespoons of Epsom salts to the water.
4. Tell them to stir well. The solution should be cloudy.
5. Direct students to use this solution to paint a design on the sheet of paper. (Remind them to stir the solution occasionally as they paint.)
6. When the design is finished, have students place the paper near a window where it can begin to dry.
7. Ask students to use the microscope to look at the paper at frequent intervals until it is completely dry. Have them record their observations of any changes occurring during this time.

Part II:

1. Instruct students to place a drop of water on a slide.
2. Dissolve one or two crystals of Epsom salts in the water.
3. Let the slide dry and observe the crystals using a microscope.
4. Have students compare their results from Part I and Part II of this activity.

Part III:

1. To determine if the structure of other crystals is the same as the Epsom salts, repeat the procedure, replacing Epsom salts with table salt, alum, or sugar.
2. Ask students to record their answers to the following questions and discuss as a group:
   a. What changes did you record during the drying process?
   b. What was the shape of the crystal you observed?
   c. How could this process of drying create problems in a beach community? In a winter setting?



Lessons for the Microscope Submitted by Virginia Teachers

Teacher	School	Lesson
Tom Matteson	Stanley Elementary School Stanley	What Is It?
Jeff Weaver	Waterman Elementary School Harrisonburg	The "Write" Stuff
Candice Dupoise	Falling Spring Elementary School Hot Springs	Diffusion in Plant Cells
Dale McAllister	John C. Myers Middle School Broadway	Building a Better Mousetrap: Unbreakable Slides
Ginger Gordon	Wetsel High School Madison	Investigating Asexual Reproduction in Yeast
Fonda Zombro	Hugh K. Cassell Elementary School Waynesboro	Leaf Anatomy

What Is It?

Submitted by: Tom Matteson
Stanley Elementary School
Stanley, Virginia

Objective of Lesson: Students use the microscope and a technique called "top lighting" to develop their observation skills and explore the concept of scale.

Materials:

Several "mystery" objects (tree bark, pine needles, hair, teeth, algae, feathers, etc.)

Microscopes (at least one for each group of four students)

Flashlights or lamps for top lighting

Paper/pencils

Instructions to the Teacher:

1. Place mystery objects under microscopes and have students (in groups) use top lighting to look at an object and draw a picture of what they see. Have students write predictions about the objects.
2. Rotate the group until everyone has seen and identified each object. Ask for guesses and identify the object.
3. If time allows, repeat with more objects.
4. Ask students to write the answers to the following questions and discuss in class:
   a. Did the slide you observed match the prediction about what each object was?
   b. If your predictions were incorrect, why do you think you were incorrect?
   c. Do you think scientists in the 1700s and 1800s had a hard time convincing people about what they were seeing through the microscope? What kinds of problems do you think these early scientists had?

Top Lighting:

Most of the time we use the microscope to view light that passes through a translucent specimen. This process is called bottom lighting. An alternative strategy to use with thick or opaque specimens is top lighting. With top lighting, a flashlight or lamp is used to illuminate the surface of a specimen so one views the light reflected from the specimen.

The "Write" Stuff

Submitted by: Jeff Weaver
Waterman Elementary School
Harrisonburg, Virginia

Objective of Lesson: Students investigate the nature of writing and observe how writing utensils work by comparing and hypothesizing. Students will observe how the surface of paper is rough and has "peaks" and "valleys." Pencils only mark the high point of the paper while markers are absorbed into the paper.

Materials Required for Each Group of Students:

One square inch of writing paper

Marker

Light source (for top lighting)

Pencil

Crayon

Ink pen

Microscope

Instructions to the Teacher:

1. Have students place a clean sheet of paper under a microscope, observe the surface, and record the observations.
2. Remove paper and ask students to draw adjacent lines with each writing utensil on paper. These should include standard pencil, drawing pencil, ball point pen, marker, crayon, and ink pen.
3. Ask students to place marked paper back under the microscope and observe.
4. Discuss with students:
   a. How does the paper feel? How does it look under the microscope?
   b. Describe how each line drawn by different utensils looks under the microscope.
   c. Which utensil covers the paper completely? Why? Which utensil does not cover the paper very well? Why?
   d. Is the pencil mark easier to erase than one made by the marker? Why?

Diffusion in Plant Cells

Submitted by: Candice Dupoise
Falling Spring Elementary School
Hot Springs, Virginia

Objective of Lesson: Students inquire into the relationships that demonstrate the principle of diffusion. They learn that the effects of saltwater on freshwater plants are readily seen and can be directly attributed to the infusion of salt into the system. Although the cell contents will shrink, the cell will keep its shape because of the cell wall. The regulation of cause and effect relationships in nature allows living things to adapt and survive.

Materials:

Elodea

Salt water

Slides

Paper towels

Medicine dropper

Instructions to the Teacher:

1. Ask students to tear off an elodea leaf and place it on a slide. Add a drop of fresh water and cover it with a coverslip.
2. Have students examine the elodea under low power and sketch it.
3. Ask students to use the medicine dropper to add one or two drops of salt water to one side of the coverslip and use a paper towel to soak up excess water on the other side of the coverslip. Repeat this two more times.
4. Ask students to observe again the leaf under low power and sketch it.
5. Discuss with students:
   a. What changes occurred during the experiment?
   b. Why would your data be important for a farmer near the ocean?

Building a Better Mousetrap: Unbreakable Slides

Submitted by: Dale McAllister
John C. Myers Middle School
Broadway, Virginia

Objective of Lesson: Students learn how to prepare an inexpensive type of slide for viewing specimens.

Materials Required For Each Group of Students:

3" x 5" file card

Specimen to be mounted (insect leg, fly wing, etc.)

Pen (for labeling)

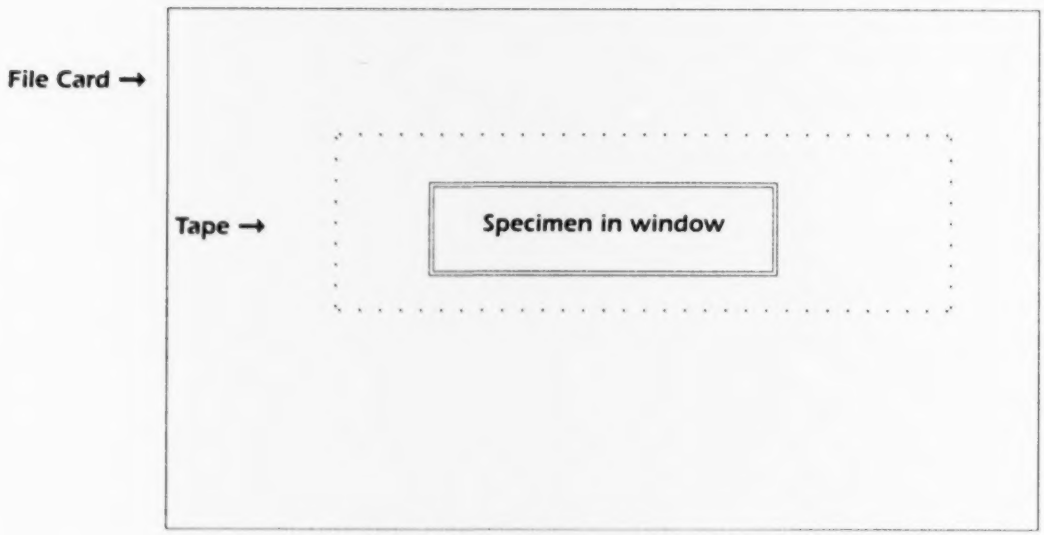
Transparent tape (not Magic Mending)

Scissors

Ruler

Instructions to the Teacher:

1. Ask students to cut a 1/2" x 2" hole in the center of an index card.
2. Ask students to place a piece of the tape over the hole. Turn the card over and mount the specimen in the center of the window.
3. Have students place another piece of tape over the specimen.
4. Tell students to write the title, date, and their name on the slide.
5. Use these new, unbreakable slides to view samples of flowers, stems, crystals, and tree bark.
6. Create a display of similar specimens and give tours to other groups of students.
7. Discuss with students:
   a. For what kinds of specimens would this technique be appropriate?
   b. What are the advantages of this slide to a regular glass slide?
   c. How could you design a slide to house a live insect specimen.



Investigating Asexual Reproduction in Yeast

Submitted by: Ginger Gordon
Wetsel High School
Madison, Virginia

Objective of Lesson: Students investigate the many factors that affect population growth to understand the human potential in our natural world. Students will learn that factors such as temperature, moisture, light, oxygen content, and available space can affect the growth and growth rate of organisms.

Materials:

Microscope

Slides

Iodine solution

Yeast culture grown at room temperature

Yeast culture grown in refrigerator

Two medicine droppers

Coverslips

Safety goggles

Instructions to the Teacher:

Part A

1. Instruct students to put on safety goggles. Have them use a clean medicine dropper to remove a drop of material of a yeast culture grown at room temperature.
2. Ask students to place the drop on a slide along with a drop of weak iodine solution and cover with a coverslip.
3. Ask students to examine the slide under a microscope on low and then high power.
4. Ask them to find single yeast cells, budding yeast cells, and clumps and chains of yeast cells.
5. Have students draw what they see.
6. Have students estimate the number of yeast cells under high power.

Part B

1. Repeat Part A exactly except use yeast that has been grown in the refrigerator.
2. Ask students to compare the two types of yeast and discuss their conclusions with classmates.
3. Students can either write their answers to the following questions or discuss in groups:
   a. How did temperature affect the population growth of the yeast culture?
   b. What other factors might have been at work in determining the population growth of the culture?
   c. Are there lessons to learn for the human population, from the yeast population? If so, what are they?

Leaf Anatomy

Submitted by: Fonda Zombro
Hugh K. Cassell Elementary School
Waynesboro, Virginia

Objective of Lesson: Students explore, observe, and identify leaf structures from the available samples.

Materials:

Naturalist microscope

Slides (prepared by students)

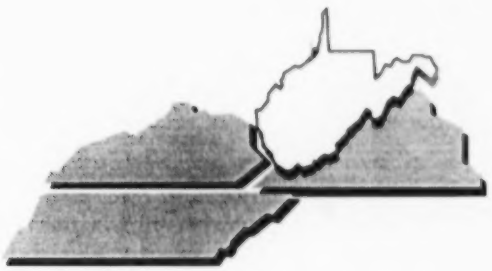
Scalpel

Leaves

Dropper

Instructions to the Teacher:

1. Prepare slides of leaves including stem and vein areas, spongy areas, and dark green areas. Be sure to include at least one cross section of a stem to show the xylem and phloem.
2. Have students view each of the slides and make a sketch and descriptive record of the structures viewed on the leaf.
3. Divide students into small groups and ask them to create a list of descriptions viewed under the microscope.
4. Have student groups use available research information to identify the described structures and share their findings with other groups.
5. Discuss with students:
   a. Were all of the slides the same? If not, describe how they were different.
   b. How were the structures related to the tasks they performed?
   c. Would you expect to find these same structures on the other types of leaves? Explain your answer.



Lessons for the Microscope Submitted by West Virginia Teachers

Teacher	School	Lesson
Susan Roberts	Wirt County Middle School Elizabeth	Using a Microscope
Linda Hager	Brooksville Elementary School Big Bend	Hair to Compare
Patricia Nicholas	Braxton County Middle School Sutton	Pond Organisms
Jackie Brillhart	Buffalo Middle School Kenova	Feathers
Eva Ellis	Madison Middle School Madison	Algae: A Useful Product
David Startzel	Danville Elementary School Danville	What Does a Bug Look Like?

Using a Microscope

Submitted by: Susan Roberts
Wirt County Middle School
Elizabeth, West Virginia

Objective of Lesson: Students use the microscope to develop their observation skills and explore the way microscopes work to magnify images.

Materials Required for Each Group of Students:

Microscope	Slides
Newspaper	Coverslips
Eyedropper	Scissors

Instructions to the Teacher:

1. Review the parts and operation of the microscope with students before allowing them to handle equipment.
2. Prepare slides with a newspaper print "e," or have students prepare their own slides.
3. Give the students the discussion questions below and see how many of them can be answered.
4. Have students place the slide on the microscope stage so the letter is over the hole in the stage. Use the stage clips to hold the slide in place.
5. Remind students as they prepare to view the microscope, to never focus down toward the stage with the coarse adjustment when they are looking through the eyepiece or they will break the slide or the objective lens. They should view the microscope from the side and lower the low power objective with the coarse adjustment until it is near the coverslip.
6. Have students look through the eyepiece and raise the body tube until they can see the letter. Then focus with the fine adjustment knob.
7. Caution them to gently move the slide to the right and then to the left.
8. Have them rotate the nosepiece to bring the medium power objective into position over the coverslip and focus with the fine adjustment knob.
9. Discuss the following questions:
   a. How does the letter e appear under low power?
   b. What happens when you move the slide to the right?
   c. What happens when you move the slide toward you?
   d. How does the letter e appear under medium power?
   e. How does a microscope help you observe?

Hair to Compare

Submitted by: Linda Hager
Brooksville Elementary School
Big Bend, West Virginia

Objective of Lesson: Students use their natural curiosity and record observations to compare characteristics of hair from a variety of sources and identify the functions of the various types of hair and fur.

Materials Required for Each Pair of Students:

Microscope

Clean slides or clear tape

Human and animal hair samples

Instructions to the Teacher:

1. Ask students to bring in hair from pets and farm animals.
2. Ask students to take a hair of their own.
3. Have students make slides with their specimens and label the sources.
4. Students will view their own hair and one from each of two friends with different hair color or type.
5. Ask students to compare color and texture, and draw what they see.
6. Ask students to view each type of animal hair. Compare these types to human hair. Compare hair from other animals.
7. Discuss with students:
   a. How is each type of hair adapted for the use of each animal?
   b. What lessons can the clothing industry learn from this activity?

Pond Organisms

Submitted by: Patricia Nicholas
Braxton County Middle School
Sutton, West Virginia

Objective of Lesson: Students explore, observe, and identify samples of one-celled organisms living in a drop of pond water. Students will learn that one-celled organisms do not have tissues, organs, and organ systems, but carry out the same life processes as humans.

Materials for Each Pair of Students:

Microscope

Samples of pond water

Slides and coverslips

Dropper

Instructions to the Teacher:

Part A

1. Ask students to place one drop of pond water on a slide and cover it with a coverslip.
2. Have students observe the slide under the lowest power on the microscope and look closely for organisms that are living in the water.
3. Ask students to draw each organism they observe and include descriptive terms which may be helpful in identifying these organisms later.

Part B

1. Direct students to use a reference book to identify the organisms they drew.
2. Ask students how they would group the organisms they observed and to list the characteristics that were the most noticeable to them.
3. Ask students to write an imaginative short story about life in a drop of pond water.

Feathers

Submitted by: Jackie Brillhart
Buffalo Middle School
Kenova, West Virginia

Objective of Lesson: Students investigate the structure of two major types of feathers, "contour" and "down." Students learn that there are little hooks, or barbs, in feathers that hold them together. Students will predict the roles played by the various feather types by observing, recording, and analyzing information about feathers.

Materials Required for Each Pair of Students:

Feathers (students can supply these)

Microscope

Hand lens

Instructions to the Teacher:

1. Display feathers students have brought in. Discuss likenesses and differences.
2. Have students choose a contour feather and a downy feather, and then work in pairs to observe the feathers with a hand lens and under the microscope.
3. Ask students to observe a contour feather using a hand lens.
4. Ask students to draw the contour feather and use a reference book to label the parts.
5. Next ask the students to look at their feathers under the microscope and draw what they see.
6. Ask students to label the barbs. Ask them why barbs are important.
7. Next, ask students to observe a downy feather using a hand lens and draw what they see.
8. Have them use a reference book to label the parts.
9. Have students observe this feather under the microscope and draw what they see.
10. Ask students to review reference books to discover what feathers are made of, what other animals have body parts made out of this same material, and how these body parts are alike.
11. Discuss the following questions:
    a.. For what are contour feathers used?
    b. How is the downy feather different from the contour feather?
    c. For what are downy feathers used?
    d. Which type of feather is used in winter clothes? Why?

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* This activity provides a good opportunity to discuss with the students the fact that federal law prohibits collecting feathers of endangered species. You may want to invite a naturalist to the classroom to discuss the issue.

Algae: A Useful Product

Submitted by: Eva Ellis
Madison Middle School
Madison, West Virginia

Objective of Lesson: Students will learn that people use many naturally occurring products to improve the quality of life. As scientists we learn to use nature to help people. During this activity students will explore the uses of diatoms, or algae, in nontraditional settings. Diatoms make up diatomaceous earth, which is used in the manufacture of silver polish, cleaners, toothpaste, air and water filters, and some types of brick and concrete.

Materials:

One jar of silver polish (Wright's Silver Cream is recommended.)

Microscope slides

Coverslips

One microscope for each pair of students

Instructions to the Teacher:

(*Safety note*: Warn students not to get the polish on the microscope lens because it is abrasive and will damage the lens.)

1. Ask students to place a small amount of silver polish on a microscope slide.
2. Tell them to add a drop of water to spread it out into a thin film.
3. Tell them to cover with a coverslip.
4. Have students observe with low power and then high power. Ask them to draw their observations and include any descriptive comments useful in describing the diatoms viewed.
5. Discuss with students:
   a. How many kinds of diatoms are in the silver polish?
   b. When and where did these diatoms live?
   c. Why do the diatoms scratch the silver?
   d. What uses do diatoms have in society?
   e. How could diatoms be used by astronauts?

What Does a Bug Look Like?

Submitted by: David G. Startzel
Danville Elementary School
Danville, West Virginia

Objective of Lesson: Students investigate magnification, microscopes, and unseen detail.

Materials:

Magnifying glasses

Free standing magnifier

Microscope

Fly or common insect

Instructions to the Teacher:

1. Ask the students to draw a picture of a fly. Discuss what they envision a fly would look like and the parts it would contain.
2. Ask the students for ideas on how we could observe a real fly. How can we see such a small insect?
3. Introduce the magnifying glasses and observe the real fly. Have students examine their drawings. Discuss what they see now that they couldn't see before.
4. Introduce the more powerful free-standing magnifier. Place a real fly under the magnifier and have the students discuss what they see. Have the students compare what they see with what they have drawn. Ask students to draw the fly using the free-standing magnifier.
5. Create a bulletin board or hall display with the students' drawings. Suggested title for the bulletin board: Come Fly with Us.
6. Introduce the microscope and discuss how it functions.
7. Prepare slides of detached wings.
8. Allow students to focus the microscope on the fly wing slide.
9. Have students compare the fly wings in their drawings to the slide.
10. Discuss how magnification helps us see things that the unaided eye cannot see.

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Appendices

Appendix A

Tennessee Science Curriculum Framework

Sample Class Safety Rules Guidelines
Lower Elementary School

Safety Rules for the Science Laboratory

Your personal safety and that of others working near you depend upon the care with which you observe the rules listed below. Become familiar with these rules and follow them AT ALL TIMES.

1. Listen carefully and follow ALL directions given by the teacher.
2. Inappropriate behavior during science activities is unacceptable.
3. Ask questions if you are unsure of what to do.
4. Never touch, taste, or smell any material unless directed by the teacher.
5. Students may be asked to secure long hair, remove jewelry, or adjust loose clothing in order to maintain safe working conditions.
6. Proper safety eyewear and protective aprons or smocks will be used when necessary.
7. Clear your work area of all extra books, papers, notebooks, etc. before beginning science activities. Always leave your work area clean and dispose of trash as directed by the teacher.
8. Always wash your hands thoroughly after each and every science activity.
9. Tell the teacher about any accident, no matter what happens.
10. Science activities should not be done at home without adult supervision.

I _____ have read, understood, and agree to follow the safety rules and conduct guidelines. I agree to follow any additional verbal or written guidelines provided by my teacher. I also understand that I am responsible for replacing any equipment or materials that I may damage.

_____ _____

Signature of Student Date Signature of Parent/Guardian Date

Tennessee Science Curriculum Framework

Sample Class Safety Rules Guidelines
Upper Elementary/Middle School

Safety Rules for the Science Laboratory

Your personal safety and that of others working near you depend upon the care with which you observe the rules listed below. Become familiar with these rules and follow them AT ALL TIMES.

1. Always pay attention to your work.
2. Never goof off during lab.
3. Never bring food or drink into the laboratory.
4. Dispose of trash and other waste as indicated by the teacher.
5. Follow directions carefully using only the amount of materials called for—more is NOT always better.
6. Wash your hands thoroughly after each and every laboratory sessions.
7. Always leave your laboratory station clean and dry.
8. Whenever you are unsure of directions, ask the teacher for help.
9. Whenever you are unsure how to use a piece of equipment, ask the teacher for help.
10. Anything you damage or break will be paid for by you.
11. Know where fire extinguishers and fire blankets are and how to use them.
12. Wear appropriate eye protection when conducting an experiment.
13. Contact lenses can cause an eye hazard so should not be worn during laboratories involving chemicals.
14. Appropriate protective aprons or smocks should be worn when conducting experiments.
15. Do not wear long, loose sleeves or a loose laboratory coat in the laboratory.
16. If you have long hair, tie it back while working in the laboratory.
17. Bracelets, dangling jewelry, and ties should be removed before working in the laboratory.
18. Only perform experiments which have been approved by your teacher.
19. Tell your teacher of any accident, no matter how minor it may seem to you.
20. Never put anything in the laboratory in your mouth unless specifically directed by the teacher.
21. Always clear your lab area of all extra books, papers, notebooks, etc. before beginning your lab work.
22. Be sure to have clear exit pathways in case of emergencies.

I _____ have read and understood the above safety rules and conduct guidelines and I agree to follow them. I also agree to follow any additional verbal or written guidelines provided by my teacher.

_____ _____

Signature of Student Date Signature of Parent/Guardian Date

Tennessee Science Curriculum Framework

Sample Class Safety Rules Guidelines
Middle School/High School

Rules of Conduct in the Laboratory

Certain rules of conduct, listed below, are advisable in a science laboratory. Study them carefully and then list a reason for each rule in your laboratory notebook.

1. Always maintain a business-like attitude.
2. Never engage in practical jokes.
3. Never bring food or drink into the laboratory room.
4. Dispose of wastes as indicated by the teacher.
5. NEVER return unused reagents to stock bottles.
6. Follow directions carefully using only the amount of materials called for—more is NOT always better.
7. Wash your hands thoroughly after each and every laboratory session.
8. Always leave your laboratory station clean and dry.
9. Be sure water and gas outlets are turned off completely after use.
10. Whenever you are unsure of a procedure, ask the teacher for help.
11. Anything you damage or break will be paid for by you.

Safety in the Laboratory

Your personal safety and that of others working near you depend upon the care with which you observe the rules listed below. Become familiar with these rules and follow them AT ALL TIMES.

1. Know where fire extinguishers and fire blankets are and how to use them.
2. Know the location of safety shower and eyewash fountain and how to use them.
3. ALWAYS wear appropriate eye protection when conducting an experiment.
4. Contact lenses can cause an eye hazard so should not be worn during certain laboratories involving chemicals.
5. Appropriate protective aprons or smocks should be worn when conducting experiments.
6. Do not wear long, loose sleeves or a loose laboratory coat in the laboratory.
7. If you have long hair, tie it back while working in the laboratory.
8. Bracelets, dangling jewelry, and ties should be removed before working in the laboratory.
9. Only perform experiments which have been approved by your teacher.
10. Notify your teacher of any accident, no matter how minor it may seem to you.
11. NEVER ingest anything in the laboratory.
12. NEVER use flammable liquids near an open flame.
13. Never pour a flammable liquid into the sink.
14. Never leave a flame unattended.
15. Check the label on ALL reagent bottles twice before using them.
16. If an acid or base spills, immediately notify your teacher.
17. When diluting acids, always put the acid into water. Remember A to W!
18. When inserting glass tubing, a glass rod, or a thermometer into a rubber stopping or rubber tubing, always protect your hand with

several thicknesses of cloth and always lubricate the glass before inserting it into the stopper or tubing.

19. When heating the contents of a test tube, keep it tilted and moving in the flame with the mouth pointed away from yourself and your neighbors.

20. When investigating odor, always waft the odor toward your nose.

I _____ have read and understood the above safety rules and conduct guidelines and I agree to follow them. I also agree to follow any additional verbal or written guidelines provided by my teacher.

_____ _____

Signature of Student Date Signature of Parent/Guardian Date

APPENDIX B

Tennessee Science Curriculum Framework
Reference List for Laboratory Safety

Below are listed a number of references which might assist you in attending to laboratory safety issues in your classroom and with your students. The references are categorized into three basic categories: (a) safety manuals, (b) chemical storage, hazards, and disposal, and (c) specific safety issues.

Safety Manuals

Accrocco, J. O., & Cinquanti, M. (!990). *Right to know: Pocket guide for laboratory employees.* Schenectady, NY: Genium Publishing Corporation.

American Chemical Society. (!990). *Safety in academic chemistry laboratories* (5th ed.). Washington, DC: Author.

American Chemical Society. (1993). *Safety in the elementary (K-6) science classroom.* Washington, DC: Author.

Flinn Scientific, Inc. (!995). *Flinn chemical catalog reference manual.* Batavia, IL: Author.

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Gerlovich, J. A. (1981). *Better science through safety* (1st ed.). Ames, IA: Iowa State University Press.

Kaufman, J. A. *Laboratory safety guidelines.* Milton, MA: Curry College.

Kucera, T. J. (Ed.). (1993). *Teaching chemistry to students with disabilities* (3rd ed.). Washington, DC: American Chemical Society.

Lab Safety Supply, Inc. (1995). *Lab safety supply catalog.* Janesville, WI: Author.

Steere, N. V. (Ed.). (1971). *Handbook of laboratory safety.* Cleveland, OH: CRC Press.

Chemical Storage, Hazards, and Disposal

American Chemical Society. (1994). *Laboratory waste management: A guidebook.* Washington, DC: Author.

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Windholz, M. (Ed.). (1983). *The Merck index: An encyclopedia of chemicals and drugs* (10th ed.). Rahway, NJ: Merck and Co.

Science Safety Issues

Flinn Scientific[1]. (1987). *Flinn fax: Poison/toxic chemical, safety in the school laboratory*. Batavia, IL: Author.

Flinn Scientific[1]. (1987). *Flinn fax: Fire extinguishers, safety in the school laboratory*. Batavia, IL: Author.

Flinn Scientific[1]. (1987). *Flinn fax: Science department ventilation, safety in the school laboratory*. Batavia, IL: Author.

National Association of Biology Teachers Policy Statements: NABT guidelines for the use of live animals; The responsible use of animals in biology classrooms, including alternatives to dissection; NABT's policy on the responsible use of animals in biology classrooms: A clarification; Role of laboratory and field instruction in biology education. Reston, VA: National Association of Biology Teachers.

[1] Flinn Scientific has developed a series of fact sheets called "Flinn Fax" which cover a wide variety of issues in school laboratories including safety. This is just one of those available.

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